Dystonic Writer`s Cramp and BoTx Experimental Procedure – Study with ARTEMG 3

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Abstract

In this study how the EMG procedure is performed is explained with indigenously developed ARTEMG system prior to acquiring the Writer`s cramp waveforms (signals) The system is a high density and high speed broadband internet connected.

Keywords: Electrode, Electromyography (EMG), Mirror movements, Writer`s cramp, Right hand, Dominant hand, Left hand, Concordant, Discordant.

Experimental procedure

Pre testing

Instrument calibration

Before each recording session, the signal was calibrated initially with a voltage of 2mV. After testing the calibration signals thoroughly the apparatus was standardized which automatically measures calibration forever.

For every testing, the signals were viewed on an Oscilloscope; they were digitized on-line and the digital signals so generated were also displayed parallelly on the monitor screen of the computer. The values of the signal streams are stored on a hard disk, for further processing later.

Electrodes

For proper sterilization, half inch portion at both upper and lower ends, of the five innocuous micro wire electrodes (each 50 micron in diameter) was burnt with a spirit lamp and then packed (sealed) in a plastic-fiber folio. Later, they were sent for gas sterilization and kept for about 12 hours in GST lab. . A hypodermic needle with a bared tip and hub was used for positioning the wire into the muscle.

Site selection

Each patient with Writer's cramp was seated comfortably in chair for sitting and writing. The electrode sites were found by palpating the muscle during a voluntary contraction and electrodes were inserted into specific-target muscles on identification of the traces on oscilloscope and based on the sound produced by oscilloscope and the neuro-physician expertise, accordingly.

The skin was always cleaned thoroughly with spirit before the electrode placement.

The placements were tested for accuracy, 'cross-talk', band connections, etc. by requesting the subject to perform several test movements (i.e., putting the particular muscle into action and detecting MUPs during minimal contraction) and test writing.

If any malfunction was found, corrective action was taken and the test was repeated. (Fig. 1)

In each patient, initially, muscle detection using these concentric needle micro-wire electrode recording was tested on Dantec's Key-Point Digital EMG machine (see Fig. 1), a commercial one channel digital EMG equipment from Denmark, Europe)., (see Fig. 1).

Fig 1: insertion of fine wire electrode in Extensor Carpi Radialis (ECR)

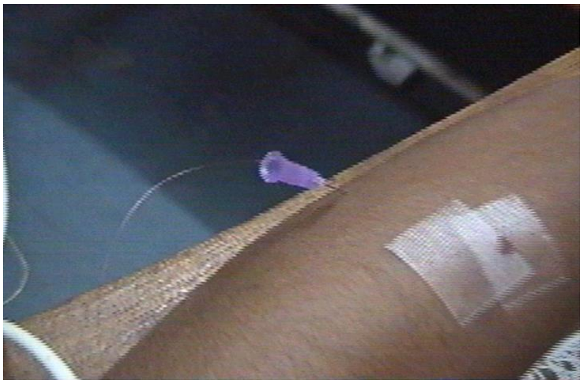

Fig 2: Checking accuracy of the fine wire electrode placement by active muscle contraction on Dantec Keypoint Digital EMG machine.

EMG Signal Acquisition

After initial checking of the electrodes on Dantec Key-Point digital EMG machine, these electrodes were connected to the differential amplifiers of the 5 channel 'prototype' machine (Fig. 3) interfaced to the Pentium-III computer.

The amplifiers have an input impedance of > 200 Mega Ohms and common mode rejection ratio of 58 dB.

Each output channel was filtered to remove motion artifact and high-frequency noise using notch band pass filters with cut-off frequencies 0.5 Hz (Lower) and 10 kHz (Upper).A sampling frequency 3kz/channel was used (maximum sampling frequency provided to each channel was 6 kHz; maximum sampling frequency of the A/D card was 40 kHz/s). On-line signal recording was done with indigenously developed real time hardware and software. All the computation was performed using C/C++ and Mat_Lab utility tools processed on (IBM compatible) Pentium computer. In addition, for each channel the integrated EMG was formed.

Testing procedure

Each patient was asked to write initially with their right hand and then with their left hand using a standard paragraph dictated to them, while the EMG was recorded from all the five channels. Each test consisted of four randomized trials, each trial lasted for 10 seconds duration, with a rest period of 1 – 2 minutes between each trials. All five channels of EMG signals data were recorded digitized using a 12-bit A/D converter and processed on-line.

The target muscles under EMG monitoring of active movement and movement of the needle was also observed visually. A close up of the signal recording can be viewed, depicted in Fig. 5.

Fig 3: writing after insertion of innocuous fine micro wire electrodes (each 50 micron diameter) and capturing EMG signals using indigenously built EMG prototype.

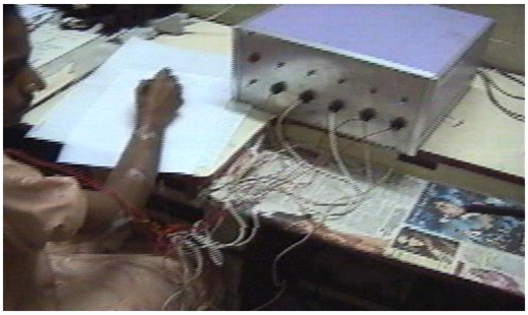

Fig 4: A close up of signal recording with indigenously developed EMG prototype

EMG data analysis

The basic signal data used in the study, consisted of the (digitized) EMG-data gathered from 5 muscles of the right hand, when the patient writing first with the right hand and then, writing with the left hand i.e., right hand writing signal (RHWS) and left hand writing signal (LHWS). Duration of signal recording was 10 seconds, with 3 KHz sampling frequency, giving 30,000 readings for each signal.

Patients were classified into two groups based on the presence of concordance or discordance of mirror movements at the wrist.

On each EMG recording, several types of descriptive features, such as, digitized data points, parameters like amplitudes, duration, centered, transposed, mean and covariance data matrices, Eigen values and Eigen vectors to perform principal component analysis (orthogonal functions). Amplitude was recorded. Analysis of the amplitude means , difference in means between right and left handed signals, standard deviations in the amplitudes, variances, t, F and p-values between RHWS and LHWS were compared using student *t*, χ^2 (*Chi-square*) and Fisher's tests.

Classifications and comparisons of ECR and ECU with respect to FCR and FCU and then both the pairs with respect to 5th muscle were made.

The noise and inconsistency or changeability is inherent in the EMG signals, especially in the case of neurology. So the use of adaptive pattern recognition techniques is indispensable. In such situations, the quantitative EMG in Writer's cramp using PCA method (a statistical signal processing technique with complex orthogonal functions which is well suited to interference EMG signals) used for effective data reduction and noise elimination appear to be very attractive for the solution of such problem because of their inherent properties: i). they pursue signal strength relatively in few components, when reconstructed, can effectively reproduce the original signal with no noise distortion (see Fig. 5), ii)they are fault tolerant, iii)Processes immense data. They pursue multiple hypotheses concurrently, make assumptions – guess values about the underlying data, probability density functions, and may create complex classification boundaries.

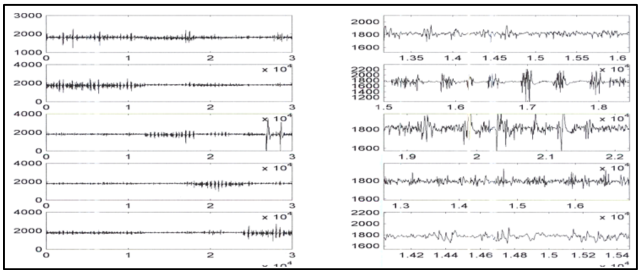

Fig. 5: Reconstructed EMG Signals

Computer analysis was done using various algorithms and techniques that are well suited for analysis of writer's cramp signals, such as, principal component analysis PCA, multivariate signal processing techniques, simple and hierarchical clustering analysis, distance function were used.

Statistical techniques – *t* test, student *t*-test, Fisher's *F*-test, student F-test, χ^2 (*Chi-square*), singular value signal decomposition (SVD), analysis of variance (ANOVA), canonical correlation analysis, EMG-EMG coherence analysis and multidimensional scaling were used as statistical tools in the present investigation.

Advanced statistical methods/ techniques employed in the present study include singular value decomposition (SVD)/ Eigen analysis, principal component analysis (PCA), Distance function simple and elegant (hierarchical) clustering, Canonical correlation for multidimensional scaling and EMG – EMG Coherence analysis were used as statistical tools in the present study.

Thus, the data analysis aspects in the present study were designed to examining the possibilities of recognizing the pattern differences in the EMG signals and correlating them with and validating them with the clinical findings (see Fig. 4 and 5).

Results and Discussion

In this study of Writer's cramp, the investigation and the diagnostic value for clinical use together with the results obtained are explained below.

12 patients (M:F: 11:1) with Writer's cramp with mean age 38.5 ± 3 years and disease duration 104 ± 126.3 months were studied. They were initially asked to write with their right (dominant) hand for 4 minutes and then with left (non-dominant) hand for another 3 to 4 minutes. During the latter phase, they were asked to maintain the right-hand resting on the table flexed on the elbow in a semi pronated position and the wrist in a neutral position, with fingers being kept relaxed in a semi-flexed position. The right hand was observed for mirror movements (MMs) while writing with their left hand.

The right hand was scored according to the Writer's Cramp Rating Scale[68,90] for the position of the wrist, thumb, index and middle fingers – both while writing with the right hand (right hand writing signal – RHWS) and also while writing with the left (left hand writing signal – LHWS) [for right hand mirror movements (MMs)]. Videotaping was done serially from two angles during the procedure. Depending on the wrist position during writing with the right hand and left hand, the MMs were scored as concordant (C) or discordant (D) if the wrist posture were in the same or different directions respectively. It was seen that patients A1, A7, A11, and A12 fall in the category of 'Discordant' (D) group whereas the other 8 patients were 'Concordant' (C). (for MMs at the wrist).

Following this, a set of five innocuous fine micro wire electrodes were inserted into the right hand ECR, ECU, FCR, FCU followed by 5th muscle, which showed dystonic MM's. The patient was then asked to write once again with the dominant right hand and then with the non-dominant left hand and EMG signals recorded parallelly in Pentium computer (see Fig. 6-9).

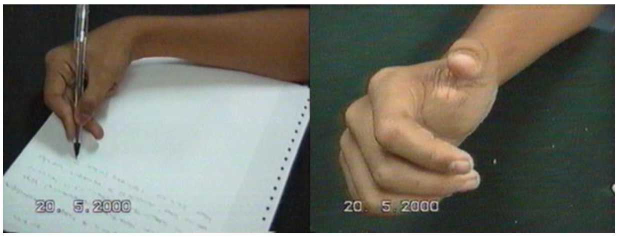

Fig. 6: Wrist flexor dystonia (right) with concordant flexor mirror dystonia (MD) in an 16 year old male. Note the discordant extensor thumb MD.

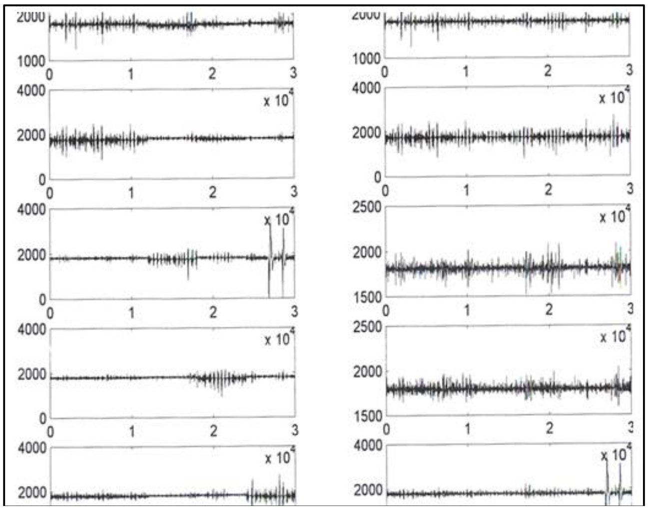

Fig. 7: EMG signals of mirror movements

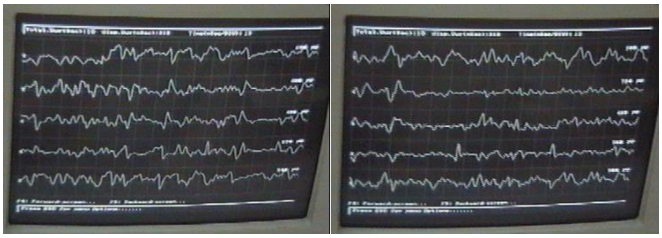

Fig. 8: On-line EMG signals

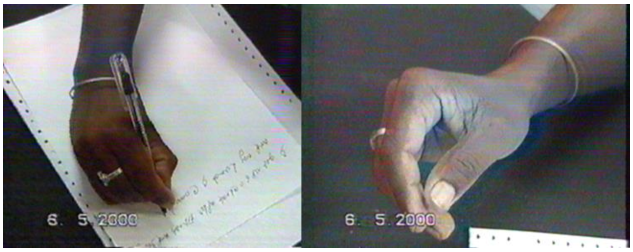

Fig. 9: Flexor wrist dystonia with discordant extensor wrist mirror movement in a 43 year old male patient**.**

In the statistical analysis, computational results obtained for the means, their differences, standard deviation, variance and F-ratios, t-values and p-values for the 5 muscle pairs are given in Tables (6,7,8,9and 10) below, respectively:

Conflicts of Interest

All contributing authors declare no conflicts of interest.

Source of Funding
None.

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How to cite: Raju VR, Raju KS. Dystonic Writer`s Cramp and BoTx Experimental Procedure – Study with ARTEMG 3. *IP Int J Aesthet Health Rejuvenation* 2020;3(4):107-10.